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APPLICATION OF CIRCULAR TOLERANCE REGIONS TO TRESSI FEATURE VEC--ETC(U)
JUL 67 E A PATRICK, L SHEN N00024-67-C-1162

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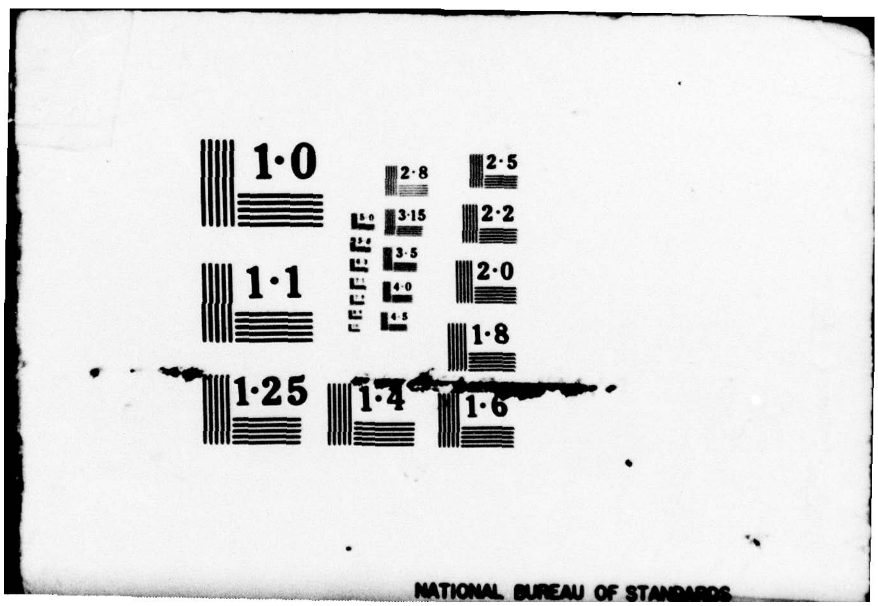
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6 APPLICATION OF CIRCULAR TOLERANCE REGIONS TO TRESSI FEATURE VECTORS. (U)

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Introduction

A new learning decision rule, the "Distribution Free, Minimum Conditional Risk Learning System" (DFMCR), is introduced to the sonar problem in reference [1]. There, its performance in processing four classes of Tressi feature vectors, is experimentally determined for one type of tolerance region construction. The tolerance region concept is a basic distribution free concept used in the definition of the DFMCR decision rule. The type of tolerance region construction used in reference [1] is a sequential construction called "bounding, binning, and sub-binning." This tolerance region construction technique has the advantage that it involves straight lines which are easy to implement in a generalized digital computer or using a small, special purpose computer.

Performance calculations for the DFMCR decision rule are given in reference [2]. These performance calculations assume that tolerance regions can be constructed from supervised samples such that a tolerance region is sufficiently small such that the underlying probability density function can be assumed uniform within the region. It is not necessary that the probability density function be uniform within the region--only that the uniformity assumption does not significantly increase the probability of error.

The tolerance regions constructed using straight lines in reference [1] become "small" as the number of training samples becomes large; however, for "small" sample sizes (such as 200, four-dimensional tressi vectors), these tolerance regions may not be as small as possible or desired. Therefore it is desirable to find tolerance regions which are "relatively small" for small sample sizes.

In reference [2] an example is given using circular tolerance regions. These tolerance regions are relatively small for small sample sizes. It is

shown in reference [2] that a DFMCR decision rule using circular tolerance regions includes such decision rules as the "nearest neighbor" decision rule as special case--thus demonstrating another powerful characteristic of the DFMCR decision rule. A disadvantage of the circular tolerance region, however, is that it is more complex to implement than the tolerance region using straight lines. The circular tolerance region offers no complexity reduction and can't be used for large sample sizes. For large sample sizes, a complexity reducing tolerance region such as constructed using straight lines is necessary.

If the classes concerned are separable, then it is expected that almost any method of constructing tolerance regions would cause the DFMCR decision rule to perform with zero probability of error. Because the sonar classes represented by the Tressi feature vectors are not separable, a circular tolerance region should produce a lower probability of error than a tolerance region constructed using straight lines. This report includes experimental results for the performance of the DFMCR decision rule, using circular tolerance regions when processing Tressi feature vectors.

Circular Tolerance Regions and DFMCR Decision Rule

The DFMCR decision rule using circular tolerance regions is described as follows: Suppose there are four sets of training vectors indexed by ω_1, ω_2, ω_3, and ω_4 respectively. Let n_i training vectors be available for each class ω_i, i=1, 2, 3, 4 such that $n=n_1+n_2+n_3+n_4$. Then a $n+1^{st}$ vector sample (called the candidate sample) is presented for recognition. The decision rule provides for storing the n_i vector samples for each class as shown for classes ω_1 and ω_2 in Figure 1, for a two-dimensional example. Suppose that the candidate sample, denoted by X^c, is as shown in Figure 1. Then, for class ω_1, construct a circle centered at X^c and passing through the v^{th} nearest sample to X^c. The example in Figure 1 is for v=3. Then the resulting circles have all the properties of tolerance regions containing 3 samples. In reference [2] it is shown that to make a decision as to which class caused X^c, decide that class whose tolerance region has the smallest volume (minimizes probability of error assuming equal class probabilities and zero-one loss functions).

Circular tolerance regions, constructed as above, were used in the DFMCR to process the same Tressi vectors previously processed using tolerance regions constructed using straight lines. The experimental performance is shown in Table 1. For all cases considered in Table 1, 150 training samples were used for each class. For recognition, 50 samples were used which were not part of the training set.

The results shown in Table 1 should be compared with those in Table 4 of reference [1]. By doing this it is seen that circular tolerance regions result is considerable improvement in performance over tolerance regions constructed using straight lines.

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The experimental procedure used in obtaining the results in Table 1 are as follows. If X^c is from a submarine class (ω_1, ω_2, or ω_3), an error is recorded only if X^c is decided from class ω_4 (non sub).

Conclusions

Circular tolerance regions give greater performance for small sample sizes than tolerance regions constructed using straight lines. For situations where the vector samples are not separable and/or the number of sample vectors available for training is "relatively small," circular tolerance regions should be used instead of tolerance regions constructed using straight lines. The circular tolerance regions used in the experiments reported were constructed with $v=3$. It was found experimentally that $v < 3$ or $v > 3$ resulted in poorer experimental performance. Theoretical results, with v as a parameter, would be desirable.

The Tressi feature vectors were used in the experiments reported herein for the purpose of comparison.

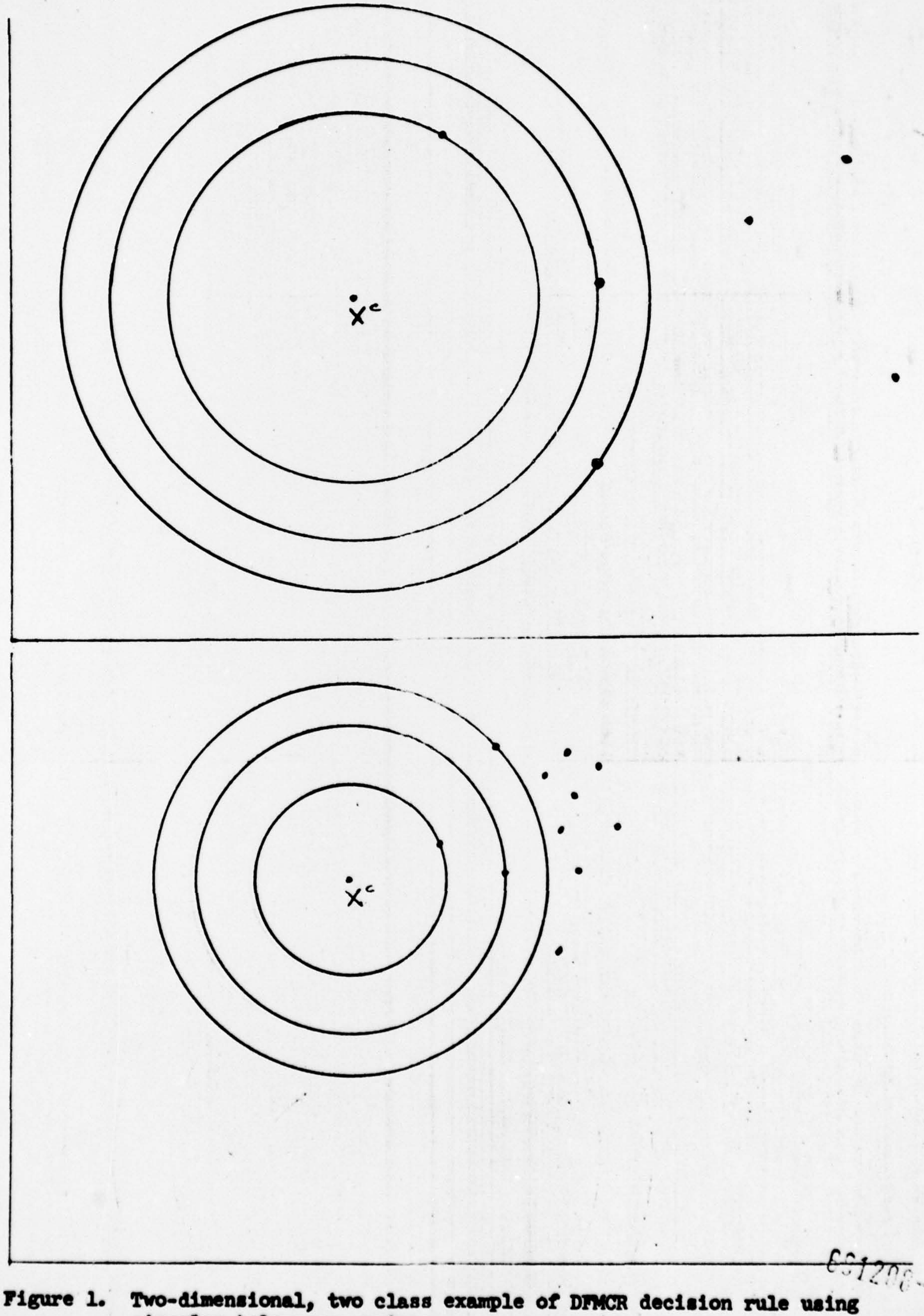

Figure 1. Two-dimensional, two class example of DFMCR decision rule using circular tolerance regions.

Training Samples				Percent Correct For 50 Recognition Samples				v : Number of Samples in Circular Tolerance Region
ω_1	ω_2	ω_3	ω_4	ω_1	ω_2	ω_3	ω_4	
150	0	0	150	92%	---	---	80%	3
150	150	0	150	88%	70%	---	64%	3
150	0	150	150	88%	---	84%	68%	3
150	150	150	150	88%	76%	92%	62%	3
0	0	150	150	---	---	78%	76%	3
0	150	0	150	---	62%	---	78%	3

ω_1 : 0551 2 ms, complete, sub, snorkling, constant aspect beam, high speed, short range

ω_2 : 0634 2 ms, complete, sub, shallow, changing aspect unknown, low speed, short range

ω_3 : 0655 2 ms, complete, sub, shallow, constant aspect quarter, high speed, short range

ω_4 : 0030 2 ms, complete, non-sub, unknown

Table 1. Decision based on one Tressi vector. Vectors used for recognition different from vectors used for training.

REFERENCES

[1] "Nonsupervised Sampleset Construction Techniques" (U), Final report on Contract No. NObsr 95285 Ser 0253-524, E. A. Patrick Principal Investigator, March 1, 1967.

[2] "Introduction to the Performance of Distribution Free Minimum Conditional Risk Learning Systems," Purdue University, TR-EE 67-12, July 1967, performed on Contract No. N00024-67-C-1162.